DOCUMENT RESUME

ED 332 863 SE 051 941

TITLE	Vision Senior High Science Programs.
INSTITUTION	Alberta Dept. of Education, Edmonton.
PUB DATE	90
NOTE	27p.; For a related document, see ED 291 364.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Biology; Chemistry; *Course Content; Curriculum Guides; Experiential Learning; General Science; Graduation Requirements; High Schools; Physics; Problem Solving; *Program Descriptions; Science and Society; *Science Curriculum; Science Education; *Scientific Literacy; *Secondary School Science; Student Attitudes; Technology; Thinking Skills
IDENTIFIERS	*Alberta

ABSTRACT

This document describes a programs designed to help students attain the scientific awareness needed to function as effective members of society. The Senior High Science Programs (Alberta, Canada) will focus on students learning the big interconnecting ideas and principles of science; place an increased emphasis on developing methods of inquiry that characterize the study of science; expect students to show an appreciation for the roles of science and technology in understanding nature; and maintain a life long interest in science. Discussions on the Biology 20/30, the Chemistry 20/30, and the Physics 20/30 programs are included. Each discussion includes key science concepts, learner expectations, program overviews, and course overviews. A basic resource checklist for each program is also included for the use of potential suppliers of instructional materials who have been invited to submit such materials for field testing. (KR)

VISION

Senior High Science Programs

NOTE: The VISION provides the framework to be used in developing the Senior High Science programs. It includes the curriculum components that will be addressed in each program.

Vision Senior High Science Programs

The Senior High Science Programs will help all students attain the scientific awareness needed to function as effective members of society. Students will be able to pursue further studies and careers in science, and come to better understand themselves and the world around them. To achieve this, appropriate curriculum components are identified, and approached from a common philosophical position in each science course. These components include expected student knowledge, skills and attitudes.

The Senior High Science Programs focus on students learning the big interconnecting ideas and principles. These ideas, or major principles, originate from science knowledge that transcends and unifies the natural science disciplines. These major ideas include change, diversity, energy, equilibrium, matter and systems; the process by which scientific knowledge is developed including the role of experimental evidence; and the connections among science, technology and society. The ideas will also form a framework for the curriculum, provide continuity with the junior high program and build on students' previous learning.

The Senior High Science Programs place an increased emphasis on developing methods of inquiry that characterize the study of science. For example, students will further their ability to ask questions, investigate and experiment; gather, analyze and assess scientific information; and test scientific principles and their applications. They will develop their problem-solving ability and use technology appropriately. By providing students with opportunities to develop and apply these skills, they will better understand the knowledge they have acquired.

Students will be expected to show an appreciation for the roles of science and technology in understanding nature and maintain a life long interest in science. They will possess positive attitudes toward and an enthusiasm for science.

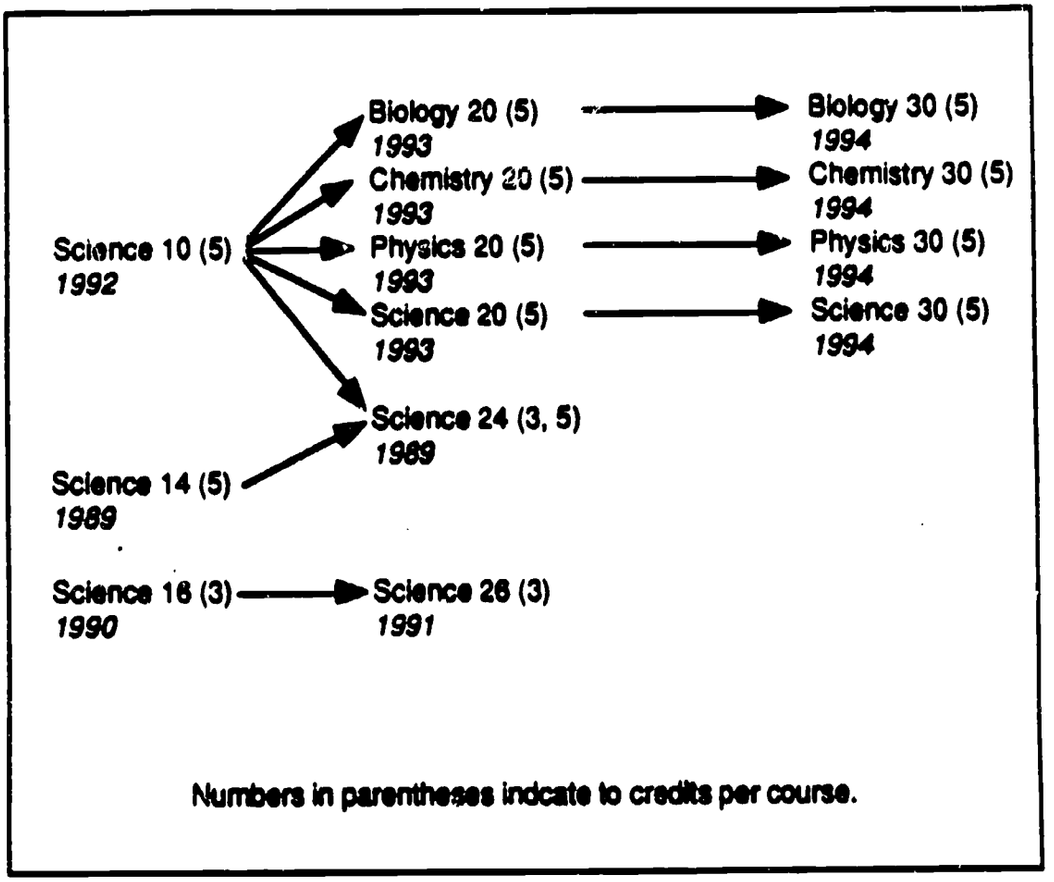
The learning context is an integral part of the Senior High Science Programs. The context is intended to foster the expected attitudes in students, further the development of students' skills, and increase students' understanding of science knowledge, science process, and the connections among science, technology and society. The context for learning will be relevant to students' personal life so they will experience science as interesting and dynamic. Learning opportunities will be made meaningful by providing concrete experiences which students can relate to their world.

The Senior High Science Programs places students at the centre. Students are active learners and will assume increased responsibility for their learning.

This provides the framework for the development of programs including Science 10-20-30, Biology 20-30, Chemistry 20-30, Physics 20-30, Science 14-24 and Science 16-26. The programs will have a common rationale and philosophy, goals and general learner expectations. As well, each program will have specific learner expectations and standards of achievement.

The Senior High Science Programs including respective courses, with credit designations and implementation timelines, are outlined on the following page.

Vision Senior High Science Programs



DRAFT DISCUSSION PAPER ON PROPOSED BIOLOGY 20/30 PROGRAM

KEY SCIENCE CONCEPTS

The program will address the biological sciences in the context of six major themes common to all the high school science programs:

- *Change*: how all natural entities are modified over time, how the direction of change might be predicted, and, in some instances, how change can be controlled.
- *Diversity*: the array of living and non-living forms of matter and the procedures used to understand, classify and distinguish those forms on the basis of recurring patterns.
- *Energy*: the capacity for doing work, which drives much of what takes place in the universe through its variety of interconvertable forms.
- *Equilibrium*: the state in which opposing forces balance in a static or dynamic way.
- *Matter*: the constitutive parts and the variety of states of the material in the physical universe.
- *Systems*: the interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

PROGRAM OVERVIEW

The Biology 20/30 program emphasizes the key concepts of *science*: *energy*, *matter*, *change*, *diversity*, *systems* and *equilibrium* as they relate to the biological sciences. These conceptual themes provide a means of showing the connections between the units of study in both courses of the program, as well as allowing students to see the nature of the connections to other courses in science. The concepts provide a framework for teachers to show students how individual sections of the program relate to the big ideas of science.

In addition to developing a solid understanding of the fundamental concepts of science and the principles of the biological sciences, Biology 20/30 has the goal of educating students about the nature of the biological sciences, of technology and of the interaction between biological sciences and technology. Students must be aware of the tremendous impact of biological sciences and technology on society, but at the same time they must be aware of the roles and limitations of biological sciences, science in general and of technology in problem solving in a societal context.

COURSE OVERVIEW: BIOLOGY 20

The major science concepts developed in this course are *systems*, *equilibrium*, *energy* and *matter*. *Diversity* and *change* are subordinate themes that are also addressed. The major concepts allow connections to be drawn between the four units of the course and between all eight units in the two courses in the program.

Biology 20 consists of four units of study:

Unit 1 The Biosphere
Unit 2 Cellular Matter and Energy Flows

Unit 3 Matter and Energy Exchange in Ecosystems
Unit 4 Matter and Energy Exchange by the Human Organism

Unit 1 focuses on the dynamic *equilibria* that exist for *matter* and *energy* in the biosphere, and the *systems* that regulate those equilibria. In Unit 2, *energy* from the environment is traced through photosynthetic and cellular respiratory *systems* with the associated cycling of *matter* in the form of carbon. Unit 3 examines the characteristics of some of the *ecosystems* that go to make up the biosphere, and the interactions of the organisms mediating the flow of *matter* and *energy* through those *ecosystems*. The unit closes with a discussion of how organisms evolve to fill available niches in *ecosystems*. The particular case of the human organism *system* and its *matter* and *energy* exchanges with the environment is examined in Unit 4, along with its biotic interactions with pathogenic organisms.

Unit 1: The Biosphere

The major concept in this unit is that by the exchange of *matter* and *energy*, the biosphere *system* maintains a dynamic *equilibrium* between itself and the rest of the universe. The unit develops themes first addressed in Science 10, Unit 1: Energy from the Sun and Unit 2: Matter and Energy in Living Systems. Initially, the role of the sun in providing the radiant *energy* to heat the earth and to drive photosynthesis is studied and it is noted that the photosynthetic *energy* is subsequently released by cellular respiration. The nature of water and the earth's elements as substrates for life is discussed during a survey of the hydrologic cycle and the biogeochemical cycles of several significant elements, and an examination of the roles of living systems in that cycling. The unit closes with a discussion of the impact of living systems on the natural composition of the atmosphere.

The nature of science is demonstrated in this unit through the role of model building to explain the nature of the cycling phenomena, and some methods of obtaining the information to put into those models can be examined as laboratory experiences. The impact of human populations on biogeochemical and hydrologic cycles can be used to illustrate the connections between science, technology and society.

This unit serves as a global introduction to the nature of *energy* and *matter* flow at the cellular level in Unit 2, the ecosystem level in Unit 3 and the organism level in Unit 4.

Unit 2: Cellular Matter and Energy Flows

This unit builds on the students' prior learning in Science 10, Unit 2: Matter and Energy in Living Systems and the previous unit. The major concept in this unit is that *energy* and *matter* cycle through subcellular *systems*. Photosynthesis is studied as the process that obtains *energy* from the environment, and cellular respiration as the process that releases it again, in part, in forms that can be used to do useful work in cells. The associated cyclical fluxes of carbon in a variety of molecules within a cell, between cells or between organisms are outlined in general. It is not the intent of this unit that students learn the molecular details of the Calvin-Benson and Kreb's cycles.

The nature of science as a means of explaining phenomena at different levels of organization by using underlying principles is developed in this unit. The *systems* under study are examined by observation, description and experimentation to develop the student's science process skills. The science, technology and society linkage is established by discussing the nature of photosynthesis as the biological process on which the province's agriculture and forestry industries are based.

This unit provides an introduction to the exchange of *matter* and *energy* between organisms within specific *ecosystems* as described in Unit 3, and to the support of physiological processes in organisms in Unit 4. It also prepares students for an examination of the role of *energy* in supporting the *systems* discussed in Biology 30.

Unit 3: Matter and Energy Exchange in Ecosystems

This unit provides a linkage between the biosphere and the cellular phenomena discussed in the two previous units by examining *matter* and *energy* flow in two diverse *ecosystems*. The biotic and abiotic factors that characterize *ecosystems* are examined in a terrestrial and an aquatic *ecosystem*. (It is the intent of the program that the chosen *ecosystems* be close to the place of learning and familiar to the learners.) The unit closes by reviewing the process of organic evolution by natural selection. That process provides a model *system* to explain how the production of *diversity* allows the selection of organisms better adapted for the roles they play in their *ecosystem*.

The nature of science can be examined by analysing how scientific theories are built and tested. The differences between hypothesis testing in biology compared to other natural sciences can be discussed. To examine the relationships among science, technology and society, students can compare scientific ways of knowing with other ways of knowing.

This unit provides the general context in which processes of exchange between organisms and their environment and some biotic interactions may be studied in the next unit. It also prepares students for a more detailed analysis of populations and communities in Biology 30.

Unit 4: Matter and Energy Exchange by the Human Organism

This unit examines physiological processes that mediate the interactions between organisms and their environment to help maintain an organism's metabolic *equilibrium*. The human organism is used as a model *system* to study these interactions. The unit builds on learning from Science 10, Unit 2: Matter and Energy in Living Systems and the other units in this course. *Matter* and *energy* are exchanged between humans and their environment during the processes of respiration, digestion and excretion. Not all cells in the human body exist at the interfaces where these processes take place. To support all the cells in the body, these processes are carried out with the aid of a circulatory *system*. That circulatory *system* is also part of a defence *system* that plays a major role in regulating the biotic interactions between pathogenic organisms from the environment and the human organism to maintain metabolic *equilibrium*.

In this unit, the nature of science is examined at the organism, organ system, organ, tissue and cellular levels of organization with the assistance of experimental work. Students will be required to present the results of their investigations as drawings, graphs and tables in a report format. The role of technology in maintaining *equilibrium* through exchanges with the environment or the circulation of transport fluids is evaluated. The relationships among science, technology and society can be examined in the context of preventing the transmission of communicable diseases and the ethics of maintaining the exchange *systems* by technological means.

This unit provides a structural and functional context in which control *systems* can be studied in Biology 30.

COURSE OVERVIEW: BIOLOGY 30

The major science concepts developed in this course are *change*, *diversity*, *equilibrium* and *systems*. *Matter* and *energy* are subordinate themes that are also addressed. The major concepts allow connections to be drawn between the four units of the course and between all eight units in the two courses in the program.

Biology 30 consists of four units of study:

Unit 1 Systems Regulating Change in Human Organisms
Unit 2 Reproduction and Development
Unit 3 Cells, Chromosomes and DNA
Unit 4 Change in Populations and Communities

Unit 1 focuses on chemical and electrical *systems* that regulate *change* to maintain *equilibria*, and the processes of reproduction and development as *systems* for bringing about *change* are examined in Unit 2. Both those units use the human organism as a model *system*. The themes of *diversity* and *change* run through Unit 3 as the mechanisms for passing on genetic information and causing variation are examined at a range of organizational levels. Finally, Unit 4 looks at *change* as illustrated by the genetics of populations and at the community *systems* in which populations exist.

Unit 1: Systems Regulating Change in Human Organisms

Biology 20, Unit 4 examined the biological processes that mediate the interactions between organisms and their environment. It used the human organism as a model *system* to study those interactions. This unit builds on that learning, and learning from Science 10, to examine how biological *systems* can be controlled to maintain a desirable *equilibrium* between an organism's internal environment and its external one. The maintenance of that *equilibrium* can be by metabolic or behavioural means. Again, this unit uses the human organism as the model for study.

The interaction between endocrine glands and other *systems* to maintain physiological *equilibrium* is mediated by hormones. Such interactions can be explored, in part, by reference to the biological *systems* reviewed in Biology 20. A study of the interaction between the neural and endocrine *systems* leads to an examination of the functioning of the central and peripheral nervous *systems*. Part of that neural control involves the ability to sense the environment and respond to it in voluntary and involuntary ways. That ability is important in maintaining *equilibrium* in terms of spatial orientation and also in terms of providing information to allow the human organism to enhance its survival by taking appropriate motor action.

The nature of science is illustrated by gathering data on the functioning of the control systems and building hypotheses about how the *systems* function. The hypotheses should be falsifiable in principle, even if the timeframe for the critical experiment is impractical. The control *systems* used in biological contexts may be compared to those used in technological ones. The relationships among science, technology and society can be illustrated by discussing the use of products manufactured by biotechnology to influence biological control *systems* in diseased and healthy organisms.

This unit leads to further study of control *systems* in the next unit and to postsecondary studies.

Unit 2: Reproduction and Development

All species must reproduce themselves to ensure the survival of the species. The processes associated with reproduction and development are reviewed here to illustrate their physiological regulation by using the human organism as a model *system*. The unit builds on learning on biological control *systems* from the preceding unit.

Change can be induced in the reproductive and other *systems* of organisms by hormones from a variety of glands. *Change* also occurs as gametes are produced, fuse to form zygotes and undergo development. The regulation of those processes by hormones is examined. The *systems* associated with parturition and lactation are regulated hormonally and are also reviewed.

The relationship between science and technology is illustrated by reference to methods of manipulating the reproductive process in humans and other species. The relationships among science, technology and society can be examined by debating the desirability of using such technology.

This unit leads to more detailed study of gametogenesis and genetics in the next unit and to postsecondary studies.

Unit 3: Cells, Chromosomes and DNA

In Science 10 it was noted that cells could reproduce and increase in number by dividing into similar daughter cells. This unit looks at the cell and molecular biology of that division process, mitosis, and examines its limitations in providing *diversity*. The timing of mitosis in the cell cycle is noted. The significance of meiosis as a way by which organisms can introduce *diversity* into their descendents is extended to examine how even more *diversity* may be introduced by crossing over. The timing and location of meiosis in the reproductive biology of the human organism, as outlined in the previous unit, is discussed.

The classical studies on mono- and dihybrid genetic crosses are reviewed to show how phenotypes may *change* through generations. The significance of sex chromosomes to such processes is also examined. As modern experimental methods and equipment have given us a greater ability to study cellular processes at the molecular level the unit extends the learning on classical genetics to a molecular level. The role of DNA in producing RNA, then proteins is reviewed. The principles of introducing *change* into the sequence of bases in DNA to provide new sequences and introducing those new arrangements back into cells are examined.

Students can develop their process skills in this unit by modelling the events of mitosis and meiosis, and those during genetic recombination at the chromosomal and molecular levels. Aspects of the nature of science and the connection between science and technology can be noted in this unit; e.g. the work of Mendel was lost for a time and when it was rediscovered it required advances in related fields to explain the basis for his data; and the work of McClintock, though widely available, only become really significant to the scientific community as a result of work in related fields. The relationships among science, technology and society can be evaluated by studying the nature and uses of genetic counselling, gene banks, replacement gene therapy and the alteration of the organisms used in the agriculture and forest industries.

This unit leads to a study of population genetics in the next unit and also to postsecondary study.

Unit 4: Change in Populations and Communities

This unit builds on the learning from the previous unit and relates the new learning to some of the concepts introduced in the study of *ecosystems* in Biology 20, Unit 3. Genetic principles may be used to analyse population systems, and an example is drawn with the Hardy-Weinberg *equilibrium*. The reasons for populations not being in *equilibrium* are reviewed. The growth of populations is discussed, and the growth of human populations is compared to that of populations of other species. The nature of the interactions of individuals within a population with individuals of other species is reviewed. Populations of different organisms exist in communities that may *change* over time as a result of natural or artificial events. A review of such successional events completes the unit.

The nature of science is illustrated by the use of empirical relationships to make predictions about natural *systems*, and by the role of hypothesis building to explore the limitations of the empirical *systems*. The relationships among science, technology and society can be examined through the interactions of organisms in human or natural *systems*, and the consequences of such interactions for populations and communities in those *systems*.

This unit, the course and the program may lead to careers or postsecondary study in the biological sciences.

BIOLOGY 20/30
Basic Resource Checklist

RESOURCE SUBMISSION REQUIRED INFORMATION

Format: Print ☐ Film ☐ Video ☐ Video laser disc ☐ Computer Software ☐
Other _____

Title: _____

ISBN: _____ NA ☐ Cost: _____

Components: _____ _____

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Annotation: _____

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INSTRUCTIONS:

Please indicate the degree of match between your submission and each of the following criterion by checking the appropriate box on the following scale.

CRITERIA	Some Match	Good Match	Excellent Match
A. Curricular Fit			
Biology 20			
Unit 1 The Biosphere	☐	☐	☐
Unit 2 Cellular Matter and Energy Flows	☐	☐	☐
Unit 3 Matter and Energy Exchange in Ecosystems	☐	☐	☐
Unit 4 Matter and Energy Exchange by the Human Organism	☐	☐	☐
Biology 30			
Unit 1 Systems Regulating Change in Human Organisms .	☐	☐	☐
Unit 2 Reproduction and Development	☐	☐	☐
Unit 3 Cells, Chromosomes and DNA	☐	☐	☐
Unit 4 Change in Populations and Communities	☐	☐	☐
Appropriate science and technology connections	☐	☐	☐
Appropriate science, technology and society connections	☐	☐	☐

CRITERIA	Some Match	Good Match	Excellent Match
B. Concepts, Skills and Attitudes			
Concept development (concrete to abstract)	☐	☐	☐
Flow and patterning of ideas within units is apparent	☐	☐	☐
Questions and problems within the chapter support development of conceptual understanding	☐	☐	☐
Questions and problems within the chapter support skill development (questioning, critical reasoning, problem solving, decision making, process skills, creative thinking)	☐	☐	☐
Individual chapters promote positive attitudes toward science	☐	☐	☐
Questions and problems within the chapter support attitude development	☐	☐	☐
C. Student Centredness			
Activities are student-oriented	☐	☐	☐
Projects and activities are practical and accessible	☐	☐	☐
Considerate text (logical, concrete, familiar vocabulary, relevant context, uses examples and anecdotes)	☐	☐	☐
Various learning styles are accommodated	☐	☐	☐
D. Content Features			
Special interest features	☐	☐	☐
Canadian and Albertan perspectives	☐	☐	☐
Information on various scientific and technological careers	☐	☐	☐
Glossary and index	☐	☐	☐
Photographs and illustrations appropriate to the text	☐	☐	☐
E. Components			
Availability of appropriate teacher and student support materials.			
Teachers' guide	☐	☐	☐
Masters or computer software for test items	☐	☐	☐
Masters for transparencies	☐	☐	☐
Masters for worksheets	☐	☐	☐
Students' laboratory guide	☐	☐	☐
Computer software, laser discs, videos, slides and other materials	☐	☐	☐
Supplementary activities for students	☐	☐	☐

DRAFT DISCUSSION PAPER ON PROPOSED CHEMISTRY 20/30 PROGRAM

KEY SCIENCE CONCEPTS

The key science concepts emphasized in the Chemistry 20/30 program are defined as follows:

- *Change*: how all natural entities are modified over time, how the direction of change might be predicted and, in some instances, how change can be controlled
- *Diversity*: the array of living and non-living forms of matter and the procedures used to understand, classify and distinguish those forms on the basis of recurring patterns
- *Energy*: the capacity for doing work, which drives much of what takes place in the universe through its variety of interconvertable forms
- *Equilibrium*: the state in which opposing forces or processes balance in a static or dynamic way
- *Matter*: the constitutive parts and the variety of states of the material in the physical world
- *Systems*: the interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

SPECIFIC LEARNER EXPECTATIONS

The specific learner expectations consist of the attitudes, skills and knowledge that are to be addressed in Chemistry 20 and 30. The use of the learning cycle allows students to progress from:

- the experiential exploration of a new idea or content, through
- a hypothesis-building stage where concepts are developed to describe the results of the initial exploration to
- an application phase where the hypothesis, vocabulary and patterns previously developed are applied to new situations.

Students examine phenomena in a variety of areas to show the relationships among the traditional science disciplines. Wherever possible, examples are drawn from their own experience to enable students to make the connection between the earth and the society around them, the technology that societies have developed and the nature of science itself.

PROGRAM OVERVIEW

The Chemistry 20/30 program emphasizes the key concepts of science: *energy*, *matter*, *change*, *systems*, *diversity* and *equilibrium*. These show the connections among the units of study and provide a framework for teachers to show students how individual sections of the program relate to the big ideas of science.

In addition to developing a solid understanding of the fundamental science concepts and principles, Chemistry 20/30 has the goal of educating students about the nature of science and the interaction of science and technology. Students are made aware of the tremendous impact of science and technology on society, as well as the roles and limitations of science and technology in STS problem solving.

Course Overview: Chemistry 20

Chemistry 20 consists of four units of study:

Unit 1: Solutions and Gases
Unit 2: Quantitative Relationships in Chemical Reactions
Unit 3: Chemical Bonding
Unit 4: An Introduction to Organic Compounds

Matter and chemical *change* are the themes common to all the units in Chemistry 20. An understanding of the nature of matter and analysis of its changes is essential for understanding what is happening and for predicting what will happen; control of change is essential for the design of technological systems. The principles of conservation of mass and energy help to predict and explain the changes that occur in a closed system. Chemistry 20 students are conceptually ready to begin defining matter in conceptual terms. Observations that provide evidence to support theories are stressed through experimentation, linking empirical and theoretical knowledge.

Each unit in Chemistry 20 uses a different context to investigate the nature of matter; to identify common patterns and the processes by which matter and systems are modified. Unit 1 focuses on the nature of solutions and gases by examining their properties, identifying patterns and analysing changes. In Unit 2 the quantitative relationships in chemical reactions are explored in predicting masses of substances reacted or produced as a result of chemical change. In Unit 3 models of the atom are extended to models of bonding as the properties of matter and theoretical explanations about its behaviour are linked. Unit 4 investigates organic compounds, compares them to inorganic matter and examines the connections to daily life.

Unit 1: Solutions and Gases

The major idea developed in this unit is that the properties of solutions and gases provide us with insights into the nature of *matter*. The unit builds on Grade 8 Science, Unit 1: Solutions and Substances; Grade 9 Science, Unit 5: Chemical Properties and Changes; and on Science 10, Unit 3: Matter and Energy in Chemical Change.

In this unit students study a variety of solutions, learn of the special characteristics of acids and bases, how to express concentration, and methods for handling and preparing solutions. Students learn that studying gases helps us to understand the nature of matter. They investigate quantitatively the relationships among pressure, temperature and the volume of gases.

The nature of science is exemplified by the role of evidence and the usefulness of models and theories in the quest to know more about matter. Science and technology contexts are illustrated by the applications of solutions, acids, bases in industry and in the application of technology, particularly instruments of measurement. The relationships among science, technology and society are explored in the investigation of issues related to the environmental effects of certain solutions and gases and by examples of the prevalence of solutions and gases in daily life.

Unit 2: Quantitative Relationships in Chemical Reactions

The focus of this unit is on chemical *change* and the quantitative relationships contained in the balanced chemical equation. The mole concept introduced in Science 10, Unit 3: Matter and Energy

in Chemical Change is further developed as students are required to use mathematical manipulation and stoichiometric principles to predict quantities of substances consumed or produced in chemical reactions. Students use their knowledge of solutions and gases obtained in Unit 1 of Chemistry 20 to determine quantities of dissolved species and gaseous substances.

The nature of science is exemplified by a focus on careful measurements and precise calculations in obtaining accurate results. The relationship of science, technology and society is illustrated by reactions from industrial applications of chemistry.

Unit 3: Chemical Bonding

The major concept of this unit is *matter*. Students learn about bonding theory, recalling the simple model of the atom from Science 10, Unit 3: Matter and Energy in Chemical Change and what they have learned about the properties of *matter* in their laboratory investigations in Grade 8 and 9 Science, Science 10 and in the previous two units of Chemistry 20.

A major focus of this unit is to relate theories about bonding to the properties of compounds and to develop explanations and descriptions of structure and bonding through scientific models. The concepts of oxidation-reduction and bond energy are briefly discussed providing an introduction to units 1 and 2 of Chemistry 30.

The use of scientific models and theories to explain the properties of *matter* exemplifies the nature of science. The science, technology and society connections relate to the applications of bonding theory.

Unit 4: An Introduction to Organic Compounds

The major concept of this unit is *diversity* of *matter*, using the specific example of organic compounds. This unit builds on Grade 9 Science, Unit 3: Chemical Properties and Changes, Science 10, Unit 3: Matter and Energy in Chemical Change and Unit 3: Chemical Bonding of Chemistry 20.

Students are introduced to the characteristics of organic compounds, the general nomenclature and formulas for hydrocarbon categories and their significant derivatives.

In using models to illustrate the diversity and complexity of organic compounds students learn more about the nature of science. In the science, technology and society connections students learn of the impact of organic compounds on their lives and on the environment.

Course Overview: Chemistry 30

Chemistry 30 consists of four units of study:

Unit 1: Thermochemistry
Unit 2: Electrochemistry
Unit 3: Equilibrium, Acid and Base Chemistry
Unit 4: Organic Chemistry

The themes of *systems*, *energy* and *change* are central in Chemistry 30. Also highlighted to a lesser extent are the themes of equilibrium and matter. The components of a system, which may be a collection of substances or processes, influence each other by the transfer of energy and matter. Changes to one part result in changes to other parts of the system.

Energy as it relates to chemical change is the focus of Unit 1. In Unit 2 electrochemical systems are examined and the matter and energy involved quantified. Unit 3 focuses on chemical systems at equilibrium, particularly those involving acids and bases. The major emphasis of Unit 4 is change as

it relates to chemical reactions of organic compounds in living and non-living systems.

Unit 1: Thermochemistry

Energy as it relates to chemical *change* is the focus of this unit. Students were introduced to the relationships between energy and matter in Grade 7 Science, Unit 4: Temperature and Heat Measurement. In Science 10, Unit 1: Energy from the Sun; Unit 3: Matter and Energy in Chemical Change; and Unit 4: Energy and Change, students learned that energy is involved in every physical, chemical and nuclear change that matter undergoes and practised simple problems involving the quantification of energy. Students build on previous learning as they study in greater depth the energy related to physical, chemical and nuclear changes and quantify the energy involved in chemical changes.

The activities in this unit provide an opportunity for students to learn that the process of science involves accurate measurement and careful observation to provide the empirical evidence that supports the theoretical explanations for energy changes related to changes in matter. Students are made aware of the interrelationship of science, technology and society as they exercise their creativity in the investigation of alternative energy sources and discuss the need to balance society's energy needs with various societal objectives.

Unit 2: Electrochemistry

The major concepts developed in this unit are *matter*, *energy*, *systems* and *change*. Students learned of the electrical nature of matter in Grade 9 Science, Unit 4: Electromagnetic Systems and in Science 10, Unit 3: Matter and Energy in Chemical Change. Students build on what they learned about electron transfer in Chemistry 20, Unit 3: Chemical Bonding as they predict, write and balance reaction equations specific to oxidation-reduction. There is a further development of the methods of stoichiometry as students calculate unknown quantities from oxidation-reduction reaction equations.

The nature of science is exemplified by the theoretical explanations for the behaviour of matter. The numerous practical applications of electrochemistry provide the science, technology and society connections in this unit.

Unit 3: Equilibrium, Acid and Base Chemistry

The major concepts developed in this unit are *systems*, *change* and *equilibrium*. Students have learned about solutions, the characteristics of acids and bases and have been introduced to the concepts of pH and indicators in Grade 8 Science, Unit 1: Solutions and Substances and in Grade 9 Science, Unit 5: Chemical Properties and Changes. In Science 10, Unit 3: Matter and Energy in Chemical Change, students further explored the properties of acids and bases and learned the scientific names for simple members. In Chemistry 20, Unit 1: Solutions and Gases, students calculated concentrations and pH. They were also introduced to the concept of equilibrium as it occurs in solutions.

In this unit the concept of equilibrium is expanded to a quantitative treatment in reaction systems involving ideal gases and acid and base solutions. Students apply stoichiometric methods to titration experiments, further explore indicators and are introduced to buffer systems.

The nature of science is exemplified by a historical perspective of how the concept of acids and bases has evolved from a very limited definition to a more generalized one and in the application of a mathematical model to describe equilibrium. The applications of equilibrium principles provide a science and technology connection, while the interrelationship of science, technology and society is addressed in a discussion of the acid deposition problem.

Unit 4: Organic Chemistry

The major theme of this unit is *change* as it relates to chemical reactions involving organic compounds in living and non-living systems. This unit builds directly on Chemistry 20, Unit 4: An Introduction to Organic Compounds and has links to the previous three units in Chemistry 30.

Students learn about reactions of organic substances in general and make comparisons between the reactions of organic and inorganic substances. Connections are made to the previous units of Chemistry 30 in the discussion of energy released from hydrocarbons and carbohydrates, oxidation-reduction as it relates to biochemical reactions and the chemistry of organic acids and bases.

The nature of science is exemplified by how science has helped describe the reactions of organic compounds and biochemicals. The focus on reactions that have significant industrial applications and importance in the functioning of living systems serves to illustrate the science, technology and society interrelationship.

CHEMISTRY 20/30
Basic Resource Checklist

RESOURCE SUBMISSION REQUIRED INFORMATION

Format: Print ☐ Film ☐ Video ☐ Video laser disc ☐ Computer Software ☐
Other _____

Title: _____

ISBN: _____ NA ☐ Cost: _____

Components: _____ _____

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Annotation: _____
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INSTRUCTIONS:

Please indicate the degree of match between your submission and each of the following criterion by checking the appropriate box on the following scale.

CRITERIA	Some Match	Good Match	Excellent Match
A. Curricular Fit			
Chemistry 20			
Unit 1 Solutions and Gases	☐	☐	☐
Unit 2 Quantitative Relationships in Chemical Reactions	☐	☐	☐
Unit 3 Chemical Bonding	☐	☐	☐
Unit 4 An Introduction to Organic Compounds	☐	☐	☐
Chemistry 30			
Unit 1 Thermochemistry	☐	☐	☐
Unit 2 Equilibrium, Acid and Base Chemistry	☐	☐	☐
Unit 3 Electrochemistry	☐	☐	☐
Unit 4 Organic Chemistry	☐	☐	☐
Appropriate science and technology connections	☐	☐	☐
Appropriate science, technology and society connections	☐	☐	☐

CRITERIA	Some Match	Good Match	Excellent Match
B. Concepts, Skills and Attitudes			
Concept development (concrete to abstract)	☐	☐	☐
Flow and patterning of ideas within units is apparent	☐	☐	☐
Questions and problems within the chapter support development of conceptual understanding	☐	☐	☐
Questions and problems within the chapter support skill development (questioning, critical reasoning, problem solving, decision making, process skills, creative thinking)	☐	☐	☐
Individual chapters promote positive attitudes toward science	☐	☐	☐
Questions and problems within the chapter support attitude development	☐	☐	☐
C. Student Centredness			
Activities are student-oriented	☐	☐	☐
Projects and activities are practical and accessible	☐	☐	☐
Considerate text (logical, concrete, familiar vocabulary, relevant context, uses examples and anecdotes)	☐	☐	☐
Various learning styles are accommodated	☐	☐	☐
D. Content Features			
Special interest features	☐	☐	☐
Canadian and Albertan perspectives	☐	☐	☐
Information on various scientific and technological careers	☐	☐	☐
Glossary and index	☐	☐	☐
Photographs and illustrations appropriate to the text	☐	☐	☐
E. Components			
Availability of appropriate teacher and student support materials.			
Teachers' guide	☐	☐	☐
Masters or computer software for test items	☐	☐	☐
Masters for transparencies	☐	☐	☐
Masters for worksheets	☐	☐	☐
Students' laboratory guide	☐	☐	☐
Computer software, laser discs, videos, slides and other materials	☐	☐	☐
Supplementary activities for students	☐	☐	☐

DRAFT DISCUSSION PAPER ON PROPOSED PHYSICS 20/30 PROGRAM

KEY SCIENCE CONCEPTS

The Physics 20/30 program will address physics in the context of six major themes that are common to all the high school science programs. They are:

- Change: how all natural entities are modified over time, how the direction of change might be predicted and, in some instances, how change can be controlled
- Diversity: the array of living and non-living forms of matter and the procedures used to understand, classify and distinguish those forms on the basis of recurring patterns
- Energy: the capacity for doing work, which drives much of what takes place in the universe through its variety of interconvertable forms
- Equilibrium: the state in which opposing forces or processes balance in a static or dynamic way
- Matter: the constitutive parts and the variety of states of the material in the physical world
- Systems: the interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

SPECIFIC LEARNER EXPECTATIONS

The specific learner expectations consist of the attitudes, skills and knowledge that are to be addressed in Physics 20 and 30. The use of the learning cycle allows students to progress from:

- the experiential exploration of a new idea or content, through
- a hypothesis-building stage where concepts are developed to describe the results of the initial exploration to
- an application phase where the hypothesis, vocabulary and patterns previously developed are applied to new situations.

Wherever possible, examples are drawn from their own experience to enable students to make connections between their environment, themselves, the societies around them, the technology that societies have developed and the nature of physics itself.

PROGRAM OVERVIEW

The Physics 20/30 program emphasizes the key concepts of science: *energy*, *matter*, *change*, *systems*, *diversity* and *equilibrium* as they relate to physics. These conceptual themes provide a means of showing the connections among the scientific disciplines, and provide a framework for teachers to show students how individual sections of the program relate to the big ideas of science.

In addition to developing a solid understanding of fundamental science concepts and principles,

Physics 20/30 has the goal of educating students about the nature of science and about the interaction of science and technology. Students must be aware of the tremendous impact of science and technology on society, but at the same time must be aware of the roles and limitations of physics, science in general, and technology in problem solving.

Course Overview: Physics 20

Physics 20 consists of five units of study:

Unit 1 Kinematics and Dynamics
Unit 2 Circular Motion and Gravitation
Unit 3 Mechanical Waves
Unit 4 Light
Unit 5 Nuclear Physics and Radioactivity

Energy is the key concept common to all units in Physics 20, with change and matter playing a subordinate role. Energy in its many forms causes change and determines the kind of change matter undergoes.

Unit 1 examines motion and the causes of motion. In Unit 2 the principles of motion are extended to circular motion, and lead into an investigation of gravitation. Unit 3 considers the transfer of energy by means of mechanical waves, and the characteristics of waves are studied in the context of sound. Unit 4 focuses on the nature of light, a visible form of energy. In Unit 5 a restricted study of the structure and radioactive nature of matter is conducted.

Unit 1: Kinematics and Dynamics

This unit emphasizes the key ideas of *change* and *energy* through the study of motion and the forces that cause motion. The unit extends the study of motion first introduced in Science 7, Unit 3: Force and Motion, and further developed in Science 10, Unit 4: Energy and Change, to a formal study of uniform motion, uniform accelerated motion, Newton's Laws of Motion and concludes with a formal introduction to mechanical energy, work and power. The vector nature of the quantities of motion is explored through the algebraic and graphical solution of linear motion problems. The graphing skills students have previously developed are extended to describing the type of motion represented by the graph and deriving quantities from graphs.

Scientific attitudes and skills are further developed through activities, experimentation and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of physical principles in the life of the student.

The attitudes, skills and knowledge developed in this unit provide the student with a better understanding of the impact the principles of mechanics have on our current and future lives, and a foundation for further study of mechanics in subsequent units and physics courses.

Unit 2: Circular Motion and Gravitation

This unit emphasizes the key ideas of *change*, *energy* and *systems* through the study of circular motion and gravitation. The unit extends the study of kinematics and dynamics in Unit 1 to uniform circular motion, an introduction to periodic motion. Two-dimensional vectors and Newton's laws are used to analyse and explain circular motion with uniform orbital speed. The concept of "field" is introduced to explain gravitational effects, and the role that the physical principles of circular motion had in the development of Newton's Universal Law of Gravitation is examined.

Scientific attitudes and skills are further developed through activities, experimentation and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of the principles of circular motion in current and future

technological devices.

The attitudes, skills and knowledge developed in this unit provide the student with a further understanding of the impact the principles of mechanics have on our current and future lives, and a foundation for further study of mechanics and fields in subsequent units and physics courses.

Unit 3: Mechanical Waves

This unit emphasizes the key ideas of *energy* and *matter* as they evolve through the study of mechanical waves. The unit uses a brief introduction to simple harmonic motion as a bridge from circular periodic motion to linear oscillation. The concepts of motion and energy are extended to the study of mechanical wave characteristics and behaviour. Sound is used as an example of a mechanical wave and to enhance the student's understanding of wave behaviour and characteristics.

Scientific attitudes and skills are further developed through activities, experimentation and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of the principles of mechanical waves in current and future technological devices.

The attitudes, skills and knowledge developed in this unit provide the student with a further understanding of the impact physical principles have on our current and future lives, and serve as a link to the unit on light.

Unit 4: Light

This unit emphasizes the key ideas of *energy* and *diversity* through the study of the nature and behaviour of light. The students apply prior knowledge about the characteristics and behaviour of waves, in addition to the principles and methods of ray optics, to the phenomenon of light.

Scientific attitudes and skills are further developed through activities, experimentation and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of the principles of the nature and behaviour of light in current and future technological devices. The nature of science is particularly emphasized by the attention paid to the use of models in the development of a theory of light.

The attitudes, skills and knowledge developed in this unit provide the student with an understanding of the impact the principles of physics have on our current and future lives, and a foundation for the study of electromagnetic radiation and the photon model of light in Physics 30.

Unit 5: Nuclear Physics and Radioactivity

This unit emphasizes the key ideas of *matter*, *energy* and *change* through the study of nuclear structure and radioactivity. A qualitative study of the structure of the nucleus, the primary forces in nature, radioactivity and nuclear energy introduce the student to topics of considerable scientific and social importance in our society. This unit should also equip the student with some basic knowledge required by citizens who will be making decisions about the future role of nuclear technology.

Scientific attitudes and skills are further developed through activities and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of the principles of nuclear physics in current and future technological devices and a consideration of their impact on our lives.

The attitudes, skills and knowledge developed in this unit provide the student with an understanding of the impact the principles of nuclear physics have on our current and future lives, and a foundation for the study of related topics in Physics 30.

Course Overview: Physics 30

Physics 30 consists of five units of study:

Unit 1 Conservation Laws
Unit 2 Electric Forces and Fields
Unit 3 Magnetic Forces and Fields
Unit 4 Nature of the Atom
Unit 5 Waves and Particles

The diversity of *matter* and *energy* are the predominant themes of the Physics 30 course.

In Unit 1 the key concept of *equilibrium*, as exemplified by the fundamental phenomenon of conservation in the physical universe, is emphasized. In Unit 2 the electrical nature of matter is examined. Unit 3 investigates the magnetic nature of matter, and electromagnetic interactions and technological applications. In Unit 4 the use of models, to interpret observed phenomena and develop scientific theories, is illustrated in the study of the nature of the atom. Unit 5 investigates the wave-particle duality in nature, and serves to unify the program as many of the concepts previously studied are used in the explanations of this phenomenon.

Unit 1: Conservation Laws

This unit emphasizes the key ideas of *energy* and *equilibrium* through the study of the principle of conservation in nature as it applies to energy and momentum. The energy concepts from Science 10, Unit 4: Energy and Change and Physics 20, Unit 1: Kinematics and Dynamics, are recalled and extended. The vector nature of momentum is explored through the algebraic and graphical solution of conservation of linear momentum problems. The principles learned are reinforced by analysing common and practical physical interactions.

Scientific attitudes and skills are further developed through activities, experimentation and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of conservation principles in the life of the student.

The attitudes, skills and knowledge developed in this unit provide the student with a better understanding of the impact the principles of mechanics have on our current and future lives, and a foundation for further study of mechanics in subsequent units and physics courses.

Unit 2: Electric Forces and Fields

This unit emphasizes the key idea of *diversity* as the electric nature of matter is considered in the context of electrical interactions. The student learns the principles of electrostatics and to describe the interaction of electric charges mathematically from empirical data. The concept of field, introduced in Physics 20, Unit 2: Circular Motion and Gravitation, is applied to electrical phenomena. The concepts from Physics 20, Unit 1: Kinematics and Dynamics are extended to charged particle dynamics. The unit concludes with the consideration of electric energy and simple DC circuits.

Scientific attitudes and skills are further developed through activities, experimentation and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of the principles of electric forces and fields in the life of the student.

The attitudes, skills and knowledge developed in this unit provide the student with a better understanding of the impact the principles of electricity have on our current and future lives, and a foundation for further study of electrical principles in subsequent units and physics courses.

Unit 3: Magnetic Forces and Fields

This unit emphasizes the key idea of *diversity* as the magnetic nature of matter is considered in the context of electric and magnetic interactions. The concept of field, introduced in Physics 20, Unit 2: Circular Motion and Gravitation, is applied to magnetic phenomena. The concepts from Physics 20, Unit 1: Kinematics and Dynamics, are applied to charged particle dynamics in magnetic fields. The principles of electromagnetism are further applied to an investigation of the functioning of electric motors, generators and transformers. The unit concludes with the consideration of the characteristics of the electromagnetic spectrum.

Scientific attitudes and skills are further developed through activities, experimentation and the formal reporting of results of investigations. The relationships among science, technology and society are identified through applications of the principles of electromagnetism in the life of the student.

The attitudes, skills and knowledge developed in this unit provide the student with a better understanding of the impact the principles of electricity and magnetism have on our current and future lives, and a foundation for further study of electromagnetic principles in subsequent units and physics courses.

Unit 4: Nature of the Atom

This unit emphasizes the key idea of *matter* and *diversity* as the electric nature of matter is considered in the context of developing an atomic theory. Building on previous learning from Science 10, Unit 3: Matter and Energy in Chemical Change, and Physics 20, Unit 5: Nuclear Physics and Radioactivity, development of the Bohr model of the atom is studied. The concept of quantization used by Bohr provides a link to Unit 5 where the quantization of energy transfer is emphasized. The unit concludes with the consideration of the inadequacies of the Bohr model.

Scientific attitudes and skills are further developed through activities, and the formal reporting of results of investigations. The relationships among science, technology and society are identified through the emphasis of the use of models to interpret observed phenomena and in the development of scientific theories.

The attitudes, skills and knowledge developed in this unit provide the student with a better understanding of the impact the principles of physics have on our current and future lives, and a foundation for further study in physics.

Unit 5: Waves and Particles

This unit emphasizes the key ideas of *matter* and *energy* as wave-particle duality in nature is explored. The unit builds on learning in all previous units by considering the contribution to physical theories made by the explanation of the photoelectric effect, and the hypothesis that particles can exhibit a wave nature. The unit offers an opportunity to discuss the current directions followed by research in physics.

Scientific attitudes and skills are further developed through activities, and the formal reporting of results of investigations. The relationships among science, technology and society are identified through the emphasis of the use of models to interpret observed phenomena and in the development of scientific theories.

The attitudes, skills and knowledge developed in this unit provide the student with a better understanding of the impact the principles of physics have on our current and future lives, and a foundation for further study in physics.

PHYSICS 20/30
Basic Resource Checklist

RESOURCE SUBMISSION REQUIRED INFORMATION

Format: Print ☐ Film ☐ Video ☐ Video laser disc ☐ Computer Software ☐
Other _____

Title: _____

ISBN: _____ NA ☐ Cost: _____

Components: _____ _____

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Annotation: _____

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INSTRUCTIONS:

Please indicate the degree of match between your submission and each of the following criterion by checking the appropriate box on the following scale.

CRITERIA	Some Match	Good Match	Excellent Match
A. Curricular Fit			
Physics 20			
Unit 1 Kinematics and Dynamics	☐	☐	☐
Unit 2 Circular Motion and Gravitation	☐	☐	☐
Unit 3 Mechanical Waves	☐	☐	☐
Unit 4 Light	☐	☐	☐
Unit 5 Radioactivity	☐	☐	☐
Physics 30			
Unit 1 Conservation Laws	☐	☐	☐
Unit 2 Electric Forces and Fields	☐	☐	☐
Unit 3 Magnetic Forces and Fields	☐	☐	☐
Unit 4 Nature of the Atom	☐	☐	☐
Unit 5 Waves and Particles	☐	☐	☐
Appropriate science and technology connections	☐	☐	☐
Appropriate science, technology and society connections	☐	☐	☐

CRITERIA	Some Match	Good Match	Excellent Match
B. Concepts, Skills and Attitudes			
Concept development (concrete to abstract)	☐	☐	☐
Flow and patterning of ideas within units is apparent	☐	☐	☐
Questions and problems within the chapter support development of conceptual understanding	☐	☐	☐
Questions and problems within the chapter support skill development (questioning, critical reasoning, problem solving, decision making, process skills, creative thinking)	☐	☐	☐
Individual chapters promote positive attitudes toward science	☐	☐	☐
Questions and problems within the chapter support attitude development	☐	☐	☐
C. Student Centredness			
Activities are student-oriented	☐	☐	☐
Projects and activities are practical and accessible	☐	☐	☐
Considerate text (logical, concrete, familiar vocabulary, relevant context, uses examples and anecdotes)	☐	☐	☐
Various learning styles are accommodated	☐	☐	☐
D. Content Features			
Special interest features	☐	☐	☐
Canadian and Albertan perspectives	☐	☐	☐
Information on various scientific and technological careers	☐	☐	☐
Glossary and index	☐	☐	☐
Photographs and illustrations appropriate to the text	☐	☐	☐
E. Components			
Availability of appropriate teacher and student support materials.			
Teachers' guide	☐	☐	☐
Masters or computer software for test items	☐	☐	☐
Masters for transparencies	☐	☐	☐
Masters for worksheets	☐	☐	☐
Students' laboratory guide	☐	☐	☐
Computer software, laser discs, videos, slides and other materials	☐	☐	☐
Supplementary activities for students	☐	☐	☐

PHYSICS 20/30
Basic Resource Checklist

RESOURCE SUBMISSION REQUIRED INFORMATION

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Unit 2 Circular Motion and Gravitation	☐	☐	☐
Unit 3 Mechanical Waves	☐	☐	☐
Unit 4 Light	☐	☐	☐
Unit 5 Radioactivity	☐	☐	☐
Physics 30			
Unit 1 Conservation Laws	☐	☐	☐
Unit 2 Electric Forces and Fields	☐	☐	☐
Unit 3 Magnetic Forces and Fields	☐	☐	☐
Unit 4 Nature of the Atom	☐	☐	☐
Unit 5 Waves and Particles	☐	☐	☐
Appropriate science and technology connections	☐	☐	☐
Appropriate science, technology and society connections	☐	☐	☐

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Activities are student-oriented	☐	☐	☐
Projects and activities are practical and accessible	☐	☐	☐
Considerate text (logical, concrete, familiar vocabulary, relevant context, uses examples and anecdotes)	☐	☐	☐
Various learning styles are accommodated	☐	☐	☐
D. Content Features			
Special interest features	☐	☐	☐
Canadian and Albertan perspectives	☐	☐	☐
Information on various scientific and technological careers	☐	☐	☐
Glossary and index	☐	☐	☐
Photographs and illustrations appropriate to the text	☐	☐	☐
E. Components			
Availability of appropriate teacher and student support materials.			
Teachers' guide	☐	☐	☐
Masters or computer software for test items	☐	☐	☐
Masters for transparencies	☐	☐	☐
Masters for worksheets	☐	☐	☐
Students' laborator guide	☐	☐	☐
Computer software, laser discs, videos, slides and other materials	☐	☐	☐
Supplementary activities for students	☐	☐	☐